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# Cooperative multimedia management for participative learning: A case study

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Web 2.0 has definitively twisted roles and rules within processes leading to the final online resources we all can enjoy on the Internet. Producers and consumers of Web contents merged into "prosumers", dialectically sharing their knowledge, their experiences, as well as their needs. Such novel dynamics provide a strong spin-off for e-learning methodologies and technologies, by allowing students participation along learning materials life cycle, from simple feedbacks, up to real enrichments of didactical resources. As elsewhere on the Web 2.0 scenario, inclusive aspects of e-learning 2.0 represent either a new challenge or a new opportunity.

This paper presents an e-learning 2.0 tool which is able to support users during the collaborative editing of didactical contents, from simple text to compound multimedia. Starting from a resource provided by the lecturer, learners can contribute in adding alternative contents and views, creating a multidimensional information structure. The resulting enriched material can be tailored to a specific user by resorting to automatic adaptation mechanisms. By utilizing typical Web 2.0 interfaces, our system involves all the different actors (lecturers, learning technologists, student support services, staff developers and students) to play a key role in improving the accessibility and, more generally, the effectiveness of learning materials.

*Keywords:* Accessibility; Web 2.0; E-learning 2.0; Multimedia editing

## 1. Introduction

E-learning dynamics and its related knowledge life cycle can be radically changed by the introduction of Web 2.0 technologies (Millard *et al.* 2006). Production, improvement, enjoyment and assessment of learning materials can directly involve a heterogeneous community of teachers and learners. Instead of being composed, organized and packaged into static learning objects by insiders, e-learning contents can be dynamically aggregated, classified, syndicated and shared by students, starting from a proposed initial set of resources. From blog to wiki, from podcast to media sharing, Web 2.0 applications have casted their novelty over e-learning processes, making it

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possible to reduce the distance among the involved actors and promoting the creation of an online community which shares knowledge (Downes 2005).

In such a scenario, accessibility of contents represents an open issue to be taken into account (Kelly *et al.* 2007). On the one hand, the complexity of collaborative 2.0 tools effectively represents a risk of exclusion for people with disabilities; on the other hand, the participation of people to content management is recognized as a great potential for e-learning accessibility. There are complementary ways to enrich the didactical material produced by teachers to make it accessible; examples may involve the support of the students' community, the use of new e-learning 2.0 methodologies and tools. This way, accessible e-learning can be achieved in practice, involving processes that engage all the users, from lecturers to learners, including people with disabilities, enabled to work together.

As an example, let us consider a video lecture recorded by a teacher, to be used during an e-learning course. The traditional approach implies that such a multimedia resource is recorded and, for each component stream (e.g. audio, video, slideshow), a set of textual alternatives is created and made available for the users with visual and hearing disabilities. Usually, the lecturer provides alternatives to images, while the student support service may provide captions to the lecture audio track. Finally, the product is closed and packed into a standardized learning object.

By exploiting an e-learning 2.0 approach, the authoring of multimedia resources may become a real collaborative activity, where all the actors participate to the learning content production, from its creation to delivery. Thus, for instance, given a digital lecture provided by a teacher, a collaborative annotation process can improve the quality of such a lecture and alternative resources may be added to it. Additional media resources may be created directly by learners, so as to enforce already explained concepts or to provide alternatives which can be helpful for learners with disabilities.

Here, we discuss the Wiki e-Learning Compound Multimedia Environment (We-LcoME) system, a novel e-learning platform that utilizes Web 2.0 methods, together with adaptation mechanisms, in order to offer a completely open playground for the authoring, modification and publication of multimedia learning resources. It allows describing multimedia contents, their mutual relations, their synchronization and forms of presentation (according to the device capabilities, user's preferences and their accessibility) by means of a new wiki-type language we defined. Specifically, a simple and intuitive wiki-like syntax lets us manage temporal and spatial relations among media contents composing the rich media. Furthermore, specific constructs of the language allow addressing accessibility and device-dependency issues, in order to facilitate a wider and more inclusive distribution of the created contents.

We-LCoME is based on a suitable engine—with a hybrid client/server architecture—implemented to render (or interpret) the wiki-like code, and to present a final compound multimedia, shaped into different formats. The main target is the Synchronized Multimedia Integration Language (SMIL)

standard, but different presentation alternatives can be provided for such rich media, depending on the specific user needs.

The system is able to classify contents on the basis of their accessibility by using ACCMD, the well-known standard for ACCessibility MetaData (IMS Global Learning Consortium 2004). Indeed, a metadata manager in our system is responsible for consistently storing ACCMD metadata related to each resource composing the multimedia lecture. Such information is then exploited by the adaptation system, which manipulates media elements composing the multimedia lecture, based on the specific accessibility needs of the user (these are expressed by using the ACCLIP—Accessibility for Learner Information Package-profiling standard) (IMS Global Learning Consortium 2002).

We claim that our system may really help to improve the accessibility of learning resources, thanks to the active collaboration of learners that pass from being simple users that access contents to real *prosumers* (i.e. producers and consumers) of the didactical material.

The remainder of this paper is organized as follows. In Section 2 we outline the main work related to multimedia authoring and sharing. Section 3 discusses main design issues. Section 4 presents the process at the basis of We-LCoME functioning and Section 5 shows a typical scenario of use of We-LCoME. Finally, Section 6 concludes the paper.

## 2. Related work

This section presents the main projects on multimedia authoring, with an emphasis on notable features related to delivery and collaboration paradigms.

### *2.1 Cooperation*

Sharing data is one of the main activity of Internet users. Besides the widespread peer-to-peer tools, e.g., BitTorrent (BitTorrent 2008), eMule (eMule 2008), typically today's applications for sharing content refer to Web 2.0 technologies. They allow putting online audio files, images and videos on personal blogs and virtual spaces. YouTube (YouTube 2008), GoogleVideo (GoogleVideo 2008), MySpace (MySpace 2008), Facebook (Facebook 2008), are just some few representative exemplars.

One of the main characteristics of these applications is concerned with the possibility to let the users to freely define and associate tags to the uploaded contents. As a further enhancement of this, YouTube has recently presented a novel application to add video annotations (shaped as comics-bubbles) through a Web centered interface, enriching the expressivity of presented clips. It is not (yet) a collaborative tool, but it witnesses the arising of the Web 2.0 philosophy. Obviously, these interesting systems provide users with new opportunities for distributing content to a wide community. Unfortunately, they do not offer cooperation features that, for instance, allow other users to change the published content to improve their accessibility (e.g. by adding

captions). Furthermore, they do not allow any collaborative participation during the media authoring process. An exception is represented by Kaltura (2008) that supports simple collaborative editing on video contents.

### *2.2 Accessibility and multimedia authoring*

In order to promote effective cooperation strategies to improve accessibility of multimedia contents deployed on the Web, suitable editing features are needed. Furthermore, contents must be encoded and stored according to formats which allow enriching them with additional information, so as to produce accessible contents. In this sense, a viable candidate is represented by the SMIL language, when exploited according to the Web Accessibility Initiatives (WAI) guidelines (World Wide Web Consortium 1999, 2005).

The SMIL MediaAccessibility Module (World Wide Web Consortium 2005) defines the attributes which are related to media description and their accessibility. Such a module is composed by the following attributes: **alt**, which specifies alternate text for user agents that cannot display a particular media object, **longdesc**, which allows us to specify a link to a long description of a media object, **readIndex**, which specifies the position of the current element in the order which **longdesc**, **title** and **alt** text are reading aloud by assistive devices for the current document). Despite their notable usefulness, such attributes cannot exhaustively cut off the barriers against accessibility. For instance, loss of synchronization among media elements composing the rich media is still possible.

As a matter of fact, no existing authoring applications support all the features needed to offer a real cooperative, accessible and easy-to-use compound multimedia authoring service; rather, examples exist that address just a limited subset of the issues mentioned above (Adams and Venkatesh 2003, Nack *et al.* 2004).

For instance, as it concerns with the production of multimedia contents, tools exist that allow users to edit multimedia resources using some graphical interfaces, based on timelines or flow-chart. A first example is the tool presented in Stergar and Horvat (2001). Some of these are specifically devoted to the production of SMIL documents (Limsee2 2008, 3TMAN 2008) and some others provide a multimodal user interface for the authoring of the multimedia content, so that non-standard input modalities, such as speech and gestures, can be adopted to edit the content (Rotovnik *et al.* 2003).

It is important to mention that all these are not Web-based systems, but classic desktop applications to be locally run on a single PC. More recent works have been presented which provide support for some simple form of cooperation among different users (Sung and Lee 2004, Kawamoto *et al.* 2006); some others have extended these features by providing the capability of adding meta-data to the produced contents (Foll *et al.* 2006).

On the other hand, focusing on collaborative authoring and editing activities, actual Web 2.0 applications offer simple blog and wiki-based online services. These systems promote effective and cooperative work

strategies to manage contents, but they are often limited when dealing with multimedia resources. Indeed, both blogs and wikis support a simple inclusion of multimedia resources as closed containers.

In any case, the common problem of all these cited works is that they typically do not take into consideration accessibility issues, often both in terms of the user interface made available to prosumers, and of the final produced contents. We claim that to ensure the formation of an inclusive community, the software exploited as the editor itself has to be accessible, in compliance to Authoring Tools Accessibility Guidelines (ATAG) (World Wide Web Consortium 2000).

### 2.3 Resource annotation in e-learning

From a pedagogical point of view, a main disadvantage of e-learning is that it is not possible to write annotations directly into the digital didactical material (Wolfe and Neuwirth 2001). Taking annotations, integrating them into the original content and allowing students to study on the resulting material could be of real help not only to improve the comprehensibility of the subject, but also to let students acquire the ability to elaborate concepts and to construct knowledge (Wolfe 2001).

As a confirmation of such a main lack, most pedagogical experts blame e-learning courses, stating these are mono-cognitive systems, for which teachers provide the didactical materials, while learners study and take tests and then teachers correct the tests. This is a typical descendant process (which implies the knowledge flow goes from the teacher to the student), while it has been recognized that ascendant learning processes are preferable (Clark 2003).

In e-learning, a first step to reach the latter type of learning process is to provide a mechanism to allow learners' annotations directly into the didactical material. Moreover, sharing such additional didactical materials could be a useful way to enrich the original content itself and could also be a way to improve content accessibility. For example, if we consider a content in which a figure with a scheme is presented, an annotation which explains that scheme could be useful to everyone, especially to blind learners. Re-writing a teacher's speech could be useful to those users which are deaf or those that use a device without speakers/headphones.

In achieving such activities, one of the most critical risks is obviously the provision of incorrect or ambiguous material, while it is fundamental to maintain the quality level of the resulting content (Keen 2007). Hence, teachers and tutors have to be able to check additional annotations, in order to control and to validate them. This could also be the last step of the ascendant learning process: the teacher is able to integrate the didactical content with students' annotations, answers to students' questions, hence providing more complete and clearer materials. Obviously, control phases should be included into the system so that, for instance, learners are enabled to access their mates' annotations only upon teacher's approval.

### 3. Creating a synergy

As it concerns to the state of the art, Web 2.0 related technologies do not completely couple compound multimedia authoring and collaborative tools. Whenever practices such as open editing, personal expression or wrapping one's own design around content are to deal with multimedia, they refer to "those obscure objects of desire" rather than really managing media resources.

Moving or tagging multimedia black boxes from one's own client to the World Wide Web, as it currently happens on Web 2.0 systems such as YouTube (YouTube 2008), MySpace (MySpace 2008), and Facebook (Facebook 2008), is far away from collaboratively managing and sharing contents of multimedia. Put in other words, the current process of locally producing multimedia resources and then sharing them with friends should be replaced with a cooperative, online authoring of contents, especially in the e-learning domain.

A community of learners enabled to enrich didactical contents in a multimedia lecture can really improve quality and effectiveness of learning resources. Interfaces play a notable role in opening the above cited boxes; they have to make the processes of editing as simple and friendly as possible, according to the "collective creativeness" principle of Web 2.0 users. Along the authoring phase, contemporary and sequential media inside a compound multimedia have to be shown and arranged, so as to be recognized and managed.

Once a multimedia content has to be presented to a given user, it should be rendered as a unicum, according to a consistent state. To this aim, it is worth noting that also the level accessibility of resources, together with media adaptation to different devices and users' preferences can really benefit from a collaborative editing, mostly whenever users are bound to add meta information. Indeed, metadata information associated to media resources allows us select those resources which (after some possible preliminary manipulations/customizations) can be easily presented to a given user, depending on his/her personal and technological characteristics.

Starting from a previous work (Salomoni *et al.* 2007), we designed and implemented a system which provides suitable workflows to bind users adding meta information about media contents and their accessibility. Each single media composing a resource can be created, modified, deleted from users, which become jointly responsible, together with the system, of any information about content features and their accessibility. In the rest of this Section, we describe the main characteristics of this system.

#### *3.1 The Wiki e-Learning Compound Multimedia Environment (We-LcoME) system*

Our system has been developed to allow the cooperative creation and sharing of SMIL-based multimedia resources. On We-LCoME, users (typically learners and teachers) are able to enrich the didactical material made available to the system. Specifically, they can add captions/subtitles and annotations (shaped as images, videos or audio clips and text) to the original

multimedia contents by resorting to a wiki-like interface. This open process promotes students' participation, data decentralization, assemblage from diverse sources, sharing of knowledge as well as an improvement to the efficacy of e-learning materials (Salomoni *et al.* 2007).

The use of SMIL, as a key technology to structure our multimedia presentations, is motivated by the fact that this language lets us describe the spatial and temporal relations inside compound multimedia. However, manually editing multimedia contents based on a direct use of such a markup language can become a very complex activity, closer to the (ended) insiders' age, rather than to the actual trends of content management systems, and very far from common prosumers' abilities.

Our system surmounts this potential problem. Indeed, We-LCoME transforms SMIL documents into a simpler representation, where elements of a compound flow of media can be managed and annotated in detail by users. A suitable engine rebuilds the SMIL document so as to show the results of the annotation process.

Concurrently, aiming at building a system where multimedia contents are collaboratively edited by a multitude of users, our approach follows the philosophy of wiki engines (i.e. "the wiki way"), which represent a de facto key technology for enabling user collaboration on the Web (Désilets *et al.* 2006, O'Reilly 2006, Salomoni *et al.* 2007). The syntax available in wiki systems, the so-called wikitext, typically exploits plain text with a few simple conventions so as to mark up edited contents (Ferretti *et al.* 2007), which are automatically converted into a final HTML document (Désilets *et al.* 2006). Nor a standard for syntax, neither a common grammar are shared by the wiki flavors on the net. They pursue different ways to the same speed and simplicity target. Hence, wikis have different constructs to be applied for links, images, lists and so on. In any case, a Web-based editing interface allows users to modify the wikitext source of a page, by means of a visual approach (typically a WYSIWYG interface) or directly typing the suitable syntax. We-LCoME exploits the features of Dokuwiki (DokuWiki 2008) and extends its syntax to allow the insertion of additional annotations, captions and subtitles on the media resources composing a SMIL rich media.

While, traditionally, wikis create and deliver (X)HTML pages, our Dokuwiki extension allows the user to manage multimedia (by sequencing and composing media resources on a timeline) and publish a (X)HTML+SMIL document (Salomoni *et al*. 2007). To reach this goal we have:

- defined a wiki syntax extension, by means of some wiki tags which can be used to synchronize multimedia elements.
- extended the wiki engine to convert such wiki tags and produce the HTML and SMIL document to be delivered to the users.

This general mechanism has been customized to better support e-learning accessibility by presenting to the authors a specific toolbar; each tool automatically composes the wiki-like syntax corresponding to main accessibility related functionalities (i.e. captions and subtitles). In addition,

We-LCoME supports the inclusion of annotations, that can be used to summarize, comment, schematize a given audio/video/image resource.

### *3.2 Outside the insiders dominion: the Web 2.0 heritage*

We-LCoME has been designed to provide a shared way to accessibility and effectiveness of e-learning multimedia resources.

The awkward managing of SMIL documents, which have been chosen as descriptors of compound multimedia, has been turned into the wikitext syntactic sugar, and all the typical features of a wiki, such as speed and openness to a collaborative work, have been extended to the media components. From a user point of view, the adaptation system eliminates further complications about content access. Notwithstanding these results, the collaborative editing of media provides new issues to be taken into account so as to obtain a real *lex parsimoniae*, i.e., the accessibility of noticed contents.

While we could expect the original video lecture to be accessible, i.e., with textual alternatives, captions, and any other solution to build up suitable "curb cuts", it is possible that an action, taken by a student to extend or add annotations to a media element, can spoil the availability of the lecture. On the other hand, users might improve (and often, simply, make) its accessibility by adding captions or subtitles to the media composing the video lecture. In any case, the ability of the adaptation subsystem of properly shaping contents depends upon the alternatives available for each media (added, enriched with a note or extended with a caption).

We now detail the activities any community (made of the lecturer, the students support services and the learners) can do in We-LCoME.

On the very first phase, the teacher submits his/her lecture to We-LCoME, to be delivered as a didactical material. In terms of accessibility (based on guidelines and laws), he/she is forced to ensure that every media content has an alternative resource (encoded as a different type of media element). For instance, images have to be accompanied with textual alternatives, audio speeches with subtitles/captions, and so on.

Once the lecture has been delivered, learners and the teacher him/herself are provided with a suitable interface to note, add and modify each media embedded in the lecture. By adding subtitles, schematizing textual or verbal explanations, adding annotations for any media to clarify concepts, users may improve the accessibility of the didactical material.

Finally, the lecturer has the responsibility to validate any change the community has done. The added notes may be subject to remarks and further refinements of the lecture.

### *3.3 Extended wikitext*

Each content created through the extended wiki syntax is dynamically processed by the wiki engine to produce two different target documents:

a. an (X)HTML page.
b. a SMIL document which represents the synchronized multimedia document which is referred by the former one.

The synchronized multimedia content is identified by using the **<smil>** element, which contains a set of wiki tags devoted to add multimedia resources and appropriately synchronize them. Table 1 summarizes the correspondences among our extension to the wiki syntax and the related SMIL elements.

It is worth noting that the expressive power of our wiki syntax extension is the one defined by the set of equivalent SMIL elements. In particular, using such syntax, the multimedia elements can be timed, sequentialized and parallelized to obtain complex synchronous multimedia. As well as the fact that the traditional wiki syntax reduces the expressiveness of pages (i.e. it is less complex and powerful than (X)HTML+CSS), our extension is less expressive than SMIL. Nevertheless, our wiki-like language allows the user to insert into the e-learning content a wide range of additional information to improve accessibility (i.e. captions and alternative descriptions), as shown by the example presented in Section 5.

Figure 1 presents a code fragment (representing a portion of a video lecture) written with the extended wiki syntax. The corresponding SMIL code, automatically produced by the wiki engine, is depicted in figure 2.

### *3.4 Adding accessibility metadata*

The contribution provided by users can really augment the accessibility of the lecture. However, in order to be able to exploit added media elements, meta

Table 1. Extended wikis syntax.

| Wiki symbols | Smil elements | Description |
|---|---|---|
| ^ ^ ^ | **Seq** | Adds a media resource to be in sequence |
| +++ | **par** | Adds a media resource to be played out in parallel |
| **AAA_URL_audio_AAA** | **audio** | Inserts an audio clip referring to its URL |
| **VVV_URL_video_VVV** | **video** | Inserts a video clip referring to its URL |
| **TTT_text_URL_TTT** | **text** | Inserts a text string referring to its URL |
| **SSS_URL_testo Stream_SSS** | **textstream** | Inserts a text stream referring to its URL |
| **MMM_URL_ animation_MMM** | **animation** | Inserts an animation referring to its URL |
| **III_URL_image_III** | **img** | Inserts an image referring to its URL |
| **$NNs** | **begin** | Sets the beginning of the previous media at the value of NN seconds |
| **_NNs** | **end** | Sets the end of the previous media at the value of NN seconds |
| **::NNs** | **dur** | Sets the duration of the previous media at the value NN |

```
…
  <seq>
    <video src="[VIDEO_1_URL]" region="video" dur="10s"/>
    <par>
      <video src="[VIDEO_2_URL]" region="video" dur="55s"/>
      <audio src= src="[AUDIO_2_URL]" region="audio" dur="40s"/>
      <img src=" src="[IMG_1_URL]" region="image" dur="18s"/>
      …
      …
      …
    </par>
    <video src= src="[VIDEO_3_URL]"  region="video" dur="18s"/>
  </seq>
…
```

Figure 1. Code fragment written in wikitext.

```
…
^^^ VVV[VIDEO_1_URL]VVV ::10s
+++ VVV[VIDEO_2_URL]VVV ::55s
    AAA[AUDIO2_1_URL]AAA ::40s
    III[IMG_1_URL]III ::18s
    …
    …
    …
^^^ VVV[VIDEO_3_URL]VVV ::18s
…
```

Figure 2. SMIL code fragment, corresponding to the wikitext shown in Figure 1.

information about their relationships with original contents is needed. Hence, the amount of metadata present in a rich media contents grows up together with additional contents that users may add, during the collaborative editing activity (Salomoni *et al.* 2007).

In order to describe learning objects accessibility, our system uses facilities which comply to the ACCMD standard. This way, also the adaptation system can retrieve information about available different types of content. Figure 3 depicts a fragment of ACCMD code. Such code specifies that a given video (provided with visual and auditory features), representing the original resource of the learning object, has equivalent text (with textual feature).

The sub-tree (of the metadata code) root element is the **<accessibility>** tag. It has a child node, i.e., **<resourceDescription>** tag, which contains a description of the primary resource together with information about its equivalent content. Four attributes are specified within the **<primary>** tag, which detail the features of such primary resource. In particular, the attribute **hasAuditory** indicates whether or not the resource contains auditory

```
…
<accessibility>
  <resourceDescription xmlns="http://www.imsglobal.org/xsd/accmd">
    <primary hasAuditory="true" hasTactile="false" hasVisual="true" hasText="false">
      <equivalentResource>
       text_desc.txt
      </equivalentResource>
    </primary>
  </resourceDescription>
</accessibility>
…
```

Figure 3. Example of ACCMD code.

information, **hasVisual** indicates whether or not the resource contains visual information, **hasText** indicates whether or not the resource contains text and **hasTactile** indicates whether or not the resource contains tactile information. All these attributes accept only "**true**" or "**false**" values. In turn, the <**equivalentResource**> element is a <**primary**> child and its content is the file path of a resource which is equivalent to the primary one.

A fragment of the equivalent resource ACCMD code is shown in figure 4. The <**equivalent**> tag is a child of the <**resourceDescription**> element. Basically, this tag contains information on the related primary resource, so as to define a sort of two-way link between those resources.

As it happens with SMIL, ACCMD is an awkward object to manage and, on We-LCoME, such a further overhead of information has to be put under the responsibility of users. This means that a novel complication is added. Indeed, features of resources to be added into the multimedia lecture must be inherently characterized in terms of accessibility. For instance, a subtitle/caption should be associated to a "**hasText**" attribute; perhaps information should be specified which states that it is an "**equivalentResource**" to an audio track. Similarly, an image should be characterized by the "**hasVisual**" ACCMD attribute, and so on.

In order to make this operation less time-consuming for users, we added an interface to update the ACCMD metadata along the authoring process. Analogously to what has been done with SMIL format, the information contained in ACCMD is specified using a simple and easy-to-manage interface.

Thanks to this new feature, the workflow of media editing allows users to describe relationships among media resources. Each time a new visual, textual or audio media is added as a note, a caption, a subtitle or, in general, as a new resource, users should declare their relationship (primary or alternative) with other resources. Moreover, the system states their shape (visual, textual, audio) and updates the ACCMD specification, or builds it and, finally, encapsulates meta information on learning objects descriptors.

### *3.5 Versioning capabilities*

Consistency and correctness of content is essential on e-learning. The responsibility of such an aspect necessarily belongs to the teachers, rather

```
…
<accessibility>
  <resourceDescription xmlns="http://www.imsglobal.org/xsd/accmd">
    <primary hasAuditory="false" hasTactile="false" hasVisual="false" hasText="true"/>
    <equivalent>
      <primaryResource>
        Original_video.mpg
      </primaryResource>
    </ equivalent>
  </resourceDescription>
</accessibility>
…
```

Figure 4. Example of ACCMD code.

than being left exclusively to long term adjustments, due to the iterated editing done by the learners community. Thus, in We-LCoME teachers (and maybe tutors, or student support staff members) are in charge of supervising the changes made on contents. They can accept or reject them. Such a functionality gets the shape of a versioning system. This feature is inherited from the wiki engine used to develop our system. In particular, each page is stored as a sequence of one or more versions. Whenever a page is created or modified, its current version is published with a message warning the readers it still needs the teacher's approval. Contemporarily, an e-mail is automatically sent to the teacher, who is acquainted about the presence of new or modified contents. By a Web interface inside the wiki, the lecturer can evaluate, approve or reject the published page.

With regards to the We-LCoME extended wiki syntax, figure 5 depicts the case which occurs whenever a wikitext-coded SMIL document has been modified, and a comparison is necessary. Obviously, all the metadata describing media accessibility, are associated to a particular version of it, so as to guarantee consistent information.

## 4. Production and consumption process

As it is shown in figure 6, We-LCoME chiefly integrates two different software applications, a Wiki platform and an adaptation service (Salomoni *et al.* 2008).

A user which wants to create a new content or update an existing one uses the wiki editing interface through his/her personal Web browser. The interface obviously allows uploading media files (such as images, videos, audios) that can be combined into multimedia documents. Wiki-based editing facilities to manage complex SMIL-based video lectures have been developed on top of DokuWiki, a well-known Web 2.0 platform for the collaborative editing of documents (DokuWiki 2008).

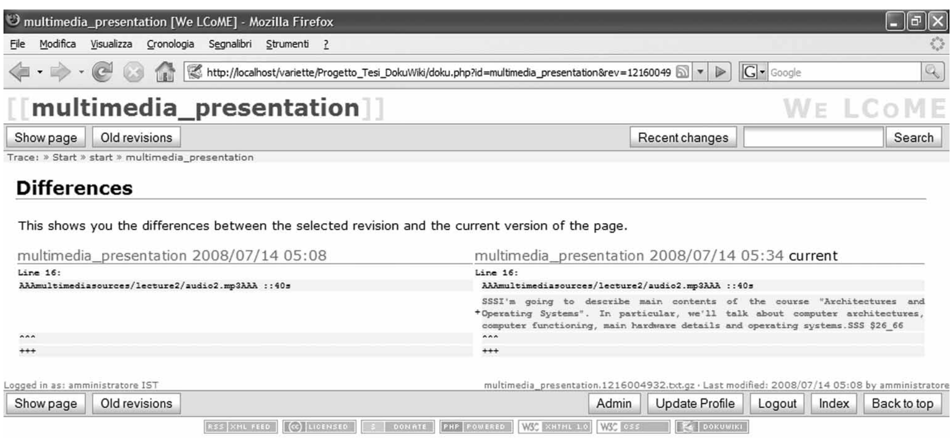


Figure 5. Differences between current and previous versions shown by the versioning function.

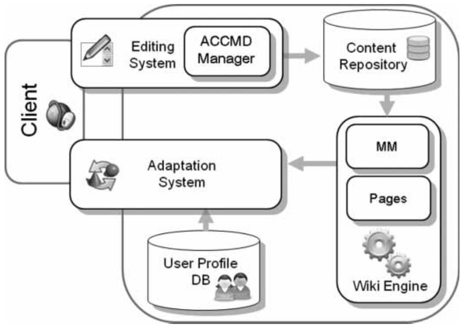


Figure 6. The We-LCoME System.

During this phase, a We-LCoME component (the ACCMD Manager) automatically produces the metadata related to the wikitext code inserted by the user. In particular, every time an alternative resource is inserted, information related to the availability of this new alternative resource is added to the ACCMD code. All edited contents (the wikitext, the corresponding ACCMD code and all the related media files) are stored in a Content Repository.

Upon request for a content by some user, the We-LCoME wiki engine (extended to manage the new wiki syntax we introduced) retrieves the wikitext code and the media elements related to the requested contents; it then produces an (X)HTML page and a SMIL document containing the synchronized multimedia presentation.

It is worth mentioning that each registered user is identified by a userID, which univocally identifies a user profile, stored in the User Profile DB. Such a profile is made of an ACCLIP specification together with a CC/PP specification (World Wide Web Consortium 2004). This approach allows taking into account both the personal preferences of the user and the technical characteristics of the exploited client device.

To allow different presentation modalities to different users, depending on their personal characteristics and on the exploited device, We-LCoME embodies a content adaptation system. Such a module is in charge of dynamically adapting the contents, by manipulation of the (X)HTML and SMIL contents together with the associated ACCMD code. The adaptation is performed through the selection of suitable media elements, and by triggering specific adaptation procedures for the involved resources. In essence, based on the user profile and on the presentation alternatives composing the requested multimedia content, the adaptation system dynamically selects those kinds of media elements that can be presented to that specific user and properly modifies the wikitext code. Hence, it guarantees that text (easily readable by a screen reader) and audio flows are employed for blind people, while only visual media are utilized for deaf ones, and lightweight media are exploited for users with resource-constrained (e.g. handheld) devices.

Moreover, transcoding policies are employed on specific media contents, so as to make them enjoyable by users. For instance, audio (video) flows can be

subject to format conversion so as to ensure their play out on specific client devices. Finally, specifications that account for the creation of complex SMIL-based presentations with multiple and parallel media flows can be properly reorganized to produce a simplified sequential (XHTML-based) presentation. This could be really useful when, for example, students with disabilities (e.g. blind users) access the lecture. This approach avoids any forms of cognitive overloads (Salomoni *et al.* 2008).

It is worth noting that the collaborative editing phase is completely independent to the adaptation phase, i.e., these are two asynchronous activities. However, it is evident that having more media alternatives available in the repository, which may have been cooperatively edited by users, augments the list of customization strategies during the adaptation process.

## 5. On the use of Wiki e-Learning Compound Multimedia Environment (We-LcoMe)

This section details on an evaluation of We-LCoME, made with the cooperation of a group of 15 students attending a course of "Operating System" of a Computer Science degree. A voluntary recruitment was made, by assigning a positive note to volunteers (for the final exam), independently from the quality of their behavior during such an assessment. This group worked on a video lecture about operating systems architecture, available through an e-learning platform used at the University of Bologna. The lecture was structured as a compound multimedia, embodying a sequence of slides and a suitably synchronized audio track explaining them. Before the assessment, students attended a preliminary talk on multimedia accessibility. They were thus introduced to the main issues and techniques on accessibility. All students were already able to use a wiki without any specific training.

Learners were asked to act on the learning material in a time window of two weeks. We tracked their activities on the video lecture by monitoring the versioning system of the wiki. In the following, we will focus on those actions which correspond to a real enhancement and of the didactical material accessibility level.

Figure 7 shows the actions that may be accomplished by users in We-LCoME, together with the resulting contents provided to learners. The video lecture, provided by the teacher (step 1), is stored in the system as a learning object. Student support staff members and learners collaboratively add captions and resources through the We-LCoME editing interface, which shows the wikitext representation of the SMIL document (steps 2a and 3a). Once annotations and alternative contents have been added on the lecture, the editing system rebuilds the SMIL document and updates the learning object repository with the modified content.

As mentioned in Section 4, We-LCoME embodies an adaptation system which allows us to adapt the final content in order to meet users' preferences and devices capabilities (Ferretti *et al.* 2007, Salomoni *et al.* 2008). As

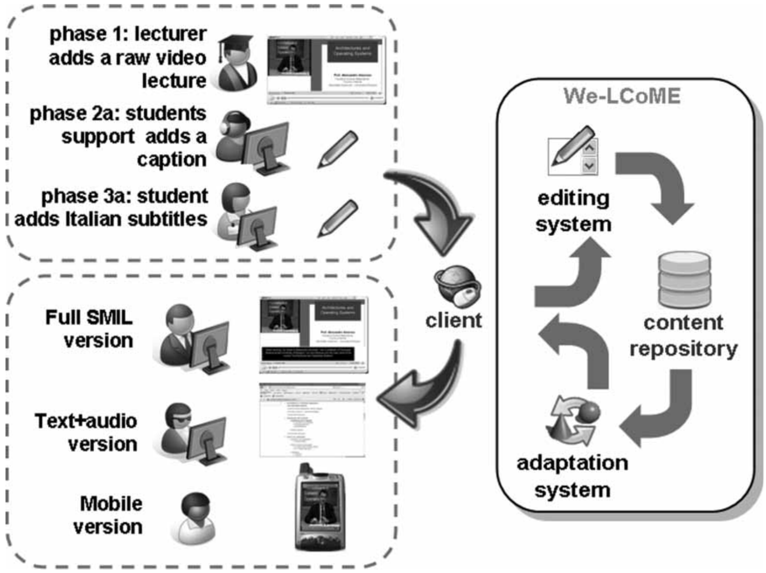


Figure 7. We-LCoME actors and functionalities.

schematized in figure 7, users who enjoy the lecture access the rich media content, shaped to meet their necessities (both physical and technological).

Figure 8 summarizes all the steps accomplished by users during the evaluation. These actions were either due to mandatory requirements (e.g. accessibility constraints), or to voluntary activities. Along the editing timeline, users added notes and media to the video lecture. The flow of the editing process was as follows:

1. The lecturer added the video lecture (step 1 in figure 8).

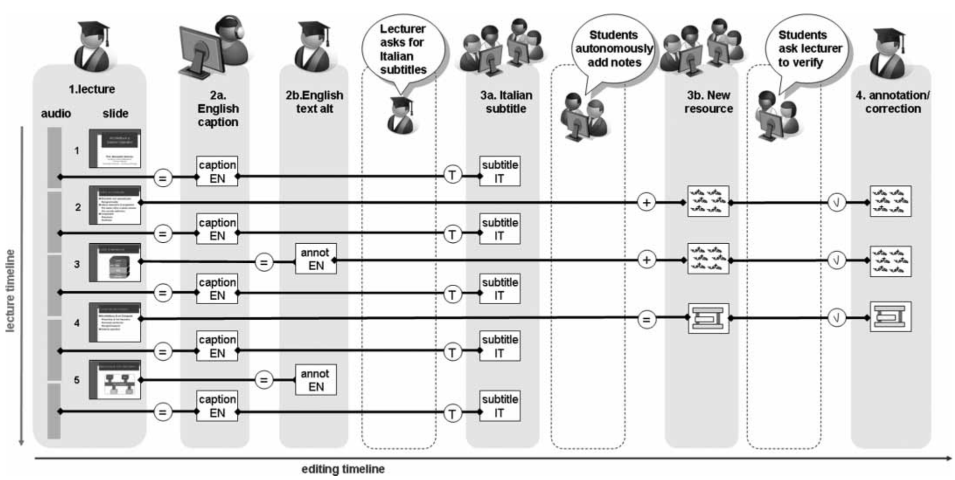


Figure 8. Dynamics of collaborative editing on a multimedia lecture.

2. According to accessibility guidelines and laws, mandatory elements were provided by the students support staff and the teacher:
   a. Captions in English were added to the audio tracks describing a group of slides (step 2a);
   b. The lecturer edited alternative texts for images on slides 3 and 5 (step 2b).

   To enforce collaborative editing, the lecturer asked students to improve the content by adding Italian subtitles.
3. Learners enjoyed the lecture and added two different kinds of content:
   a. As requested by the lecturer, students wrote Italian subtitles to be added to English captions as translations (step 3a); note that the timing of captions needed several adjustments, hence some students collaborated in such an activity, in order to obtain the corrected synchronization.
   b. Spontaneously, students added some notes to slide 2 and an alternative text for slide 3. An image with a scheme was associated to a textual explanation to better schematize some concepts of slide 4; such an image was declared as a visual alternative to this slide (step 3b). The alternative text of figure 3 was first written without underlining the semantics of the image, so that the teacher had to review and correct it.

   After adding new contents, some students asked the lecturer to verify and eventually correct them.
4. The lecturer corrected and confirmed the notes (step 4). Such an activity was made possible by means of the versioning system described on subsection 3.5.

In the following, we are going to detail how the activities mentioned above may be easily accomplished thanks to the Web-based user interface of We-LCoME. The wiki editing interface, with the wikitext related to the video lecture images and the audio elements, is shown on figure 9.

Captions in English language were added by users by using the wikitext syntax we defined, by means of the wiki editor (see figure 10). Details about such a syntax can be found in subsection 3.5 (summarizing, the $26s and _66s wikitext elements specify that the caption is related to the audio speech, starting from the 26th second of the speech up to second 66).

Figure 11 shows the wiki editing interface, with the caption already added, while figure 12 depicts a snapshot of the lecture with captions activated.

On the interface, suitable buttons, pointed out on figure 13, have been added to the traditional wiki toolbar to help the user in writing the extended wiki syntax and to allow the casting of new resources.

As to ACCMD, the syntactical sugar of the wikitext interface eases the work of the user. In certain cases, the user is asked to describe whether the added content is a primary or an alternative resource. In this case, he/she can simply press the button which shows the letter “A” (see figure 13). A pop up is opened, where the user is asked to describe the role (primary or alternative)

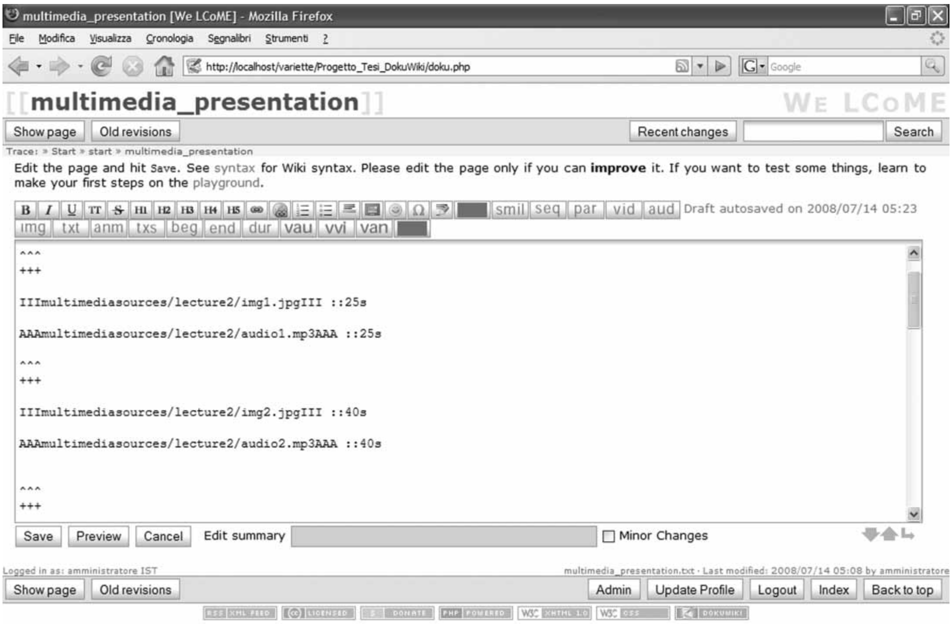


Figure 9. The wikitext editing interface.

on his/her note (see figure 14). For instance, audio1 has to be described as a primary resource (of the corresponding slide). Once the selection is made, the ACCMD chunk of code about audio1 is automatically updated.

As to captioning, based on the position of the captions into the wikitext, We-LCoME automatically identifies those resources they refer to. Once the user writes the text under an audio resource, We-LCoME associates such text to that audio. This happens in steps 2a, 2b and 3a of the scenario described above. Captioning inherently corresponds to a "**hasText**" ACCMD attribute. Hence, the ACCMD manager automatically tracks the insertion of these new captions, by adding and associating such metadata to the content.

Changes in the ACCMD specification for the audio1 media can be appreciated by looking at figure 15 (which reports the ACCMD specification before the insertion of captions) and figure 16 (ACCMD after the insertion).

Step 3b is slightly different from the previous ones. In this case, in fact, the user should declare his/her inserted image as a secondary resource for the textual slide it is related to. This is a clear demonstration of the claim stating that "*no assumption might be done about the role of a given kind of media*". The common case of a textual alternative to a visual image can be flipped as in this case.

```
AAAmultimediasources/lecture2/audio2.mp3AAA ::40s

SSSI'm going to describe main contents of the course "Architectures and Operating Systems". In
particular, we'll talk about computer architectures, computer functioning, main hardware details
and operating systems.SSS $26s_66s.
```

Figure 10. A wiki syntax fragment for captioning.

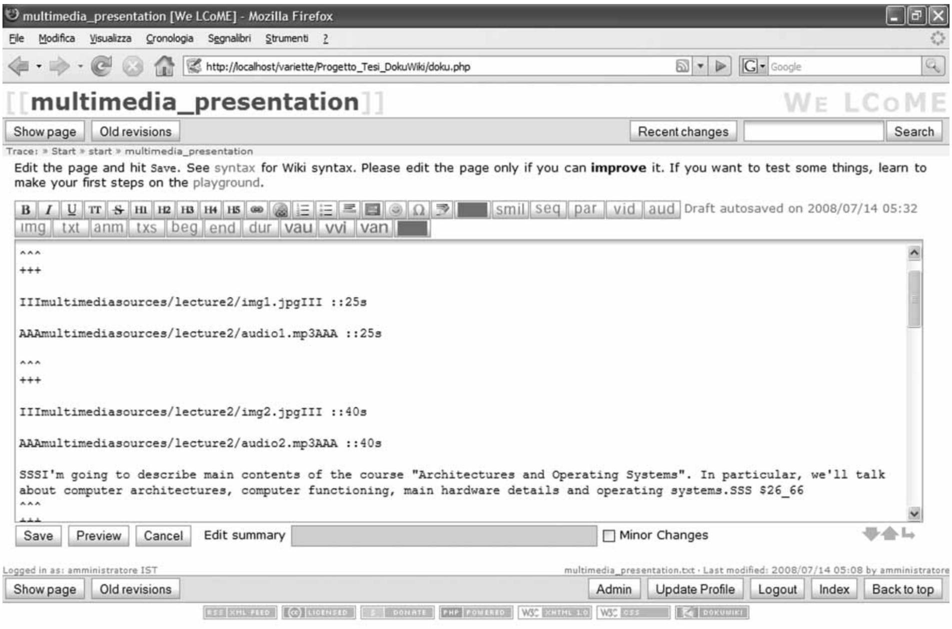


Figure 11. The wikitext editing interface.

Finally, to validate the insertion of contents (step 4), the lecturer simply confirms by pressing the check button on the toolbar (see figure 13).

Based on the (meta) information retrieved from the updated ACCMD, the adaptation subsystem is able to shape contents to meet users' necessities. Deaf

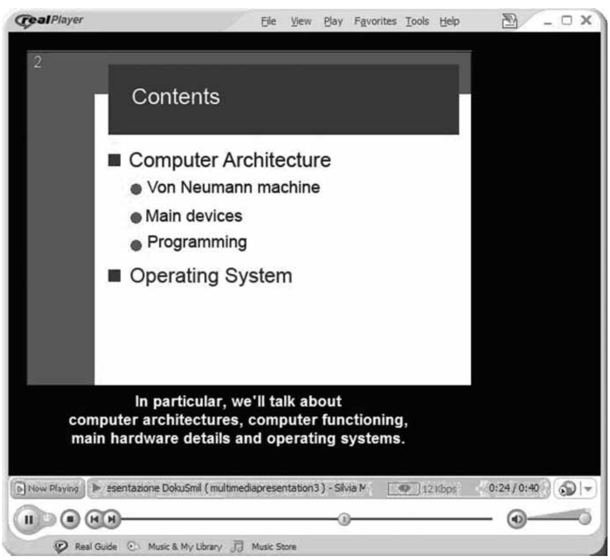


Figure 12. A snapshot of a SMIL video lecture.


Figure 13. Suitable buttons added in the toolbar.

users can access the captions or their translation, blind users can listen to the alternative description of the inserted images and so on. As we stated on the introduction, there are notable advantages for learning disabilities too. The image schematizing texts on step 4 can really benefit those ones with difficulties in understanding written information.

**6. Conclusions and future work**

We-LCoME has been designed and implemented to avoid the prospect that just black boxed e-learning contents are shared by a community of learners, as often happens with rich media resources. It is a catalyst to create and manipulate compound multimedia. Accessibility, which typically represents an open issue on multimedia resources, can be achieved through the joint work of a wider, heterogeneous community, rather than be an exclusive responsibility of teachers.

Allowing for general statements from Web 2.0 philosophy, sharing tools have been kept as simple as possible on We-LCoME, by providing a user-friendly interface to access each media of SMIL-based multimedia resources. Furthermore, suitable tools have been integrated with the system, to manage the ACCMD metadata about the accessibility of added contents and to adapt them to the user's needs and device capabilities. Finally, versioning functionalities guarantee the consistency and correctness of community-edited didactical materials. The experiment done with WE-LCoME on a video lecture has shown the effectiveness of the system on accessibility

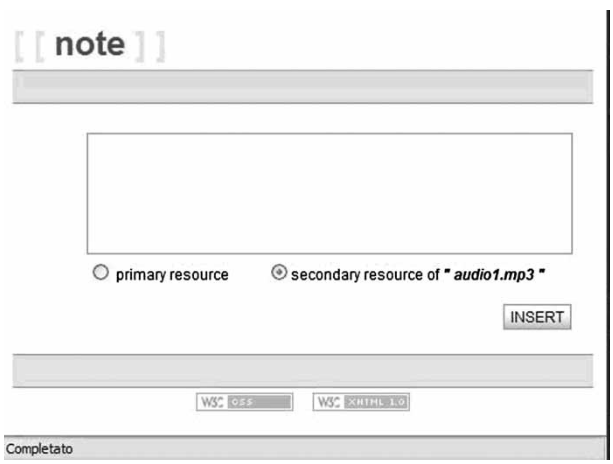


Figure 14. The ACCMD interface.

```
…
<accessibility>
  <resourceDescription>
    <primary hasAuditory="true" hasTactile="false" hasText="false" hasVisual="false"/>
  </resourceDescription>
</accessibility>
…
```

Figure 15. The ACCMD code for audio 1 resource.

```
…
<accessibility>
  <resourceDescription>
    <primary hasAuditory="true" hasTactile="false" hasText="false" hasVisual="false"/>
    <equivalentResource>
      http://www.criad.unibo.it/We-LCoME/file1.txt
    </equivalentResource>
  </resourceDescription>
</accessibility>
…
```

Figure 16. The ACCMD code for audio 1 resource after the captioning.

improvement, also confirming desired side effects coming from dialectical participation by the learners.

Future works will improve the authoring interface so as to allow the control of the spatial dimension of SMIL-based video lectures. The adaptation system, which is integrated to the We-LCoME platform, will be re-built in order to hit the mark of Web 2.0 collaborative footsteps, by sharing transcoding loads.

From an assessment point of view, a wider group of users is accessing WE-LCoME to attend an entire course of Computer Architecture. The evolution of didactical material keeps on proving itself to be accessible and effective.

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